

Surgical approaches in patients with empyema: Clinical evaluation

Empyema

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Abstract

Aim: Surgical treatment procedures for empyema are tube thoracostomy, video-assisted thoracoscopic surgery (VATS), and thoracotomy. In this study, we aimed to share the characteristics and treatment outcomes of the patients with empyema treated with surgery. **Materials and Methods:** One hundred fifty-six patients were divided into 3 groups as patients who underwent tube thoracostomy (Group 1), VATS (Group 2), and thoracotomy (Group 3). Factors affecting the application of VATS-thoracotomy instead of tube thoracostomy and the application of thoracotomy instead of VATS were identified. The results were analyzed by the Fisher's exact test. $P < 0.05$ was considered significant. **Results:** In Group 1 (n: 94), gram stain and culture results were positive in five (5%) patients, whereas negative results were found in 89 (95%). Loculation existed in five (5%) patients. In Group 2 (n: 6), in 2 patients (33%), gram stain and cultures were positive, while in 4 (67%) patients, they were negative. Loculation was present in 2 patients (33%). In Group 3 (n: 56), gram stain and cultures were positive in 19 (34%) patients, while they were negative in 37 patients (66%). Loculation existed in 53 patients (95%). The presence of positive gram stain and culture results, loculations, and purulent aspiration in thoracentesis were found to be more effective in preferring VATS-thoracotomy instead of tube thoracostomy. The presence of loculations only was found to be more effective in performing thoracotomy instead of VATS ($p < 0.05$). **Discussion:** In cases where gram stain and culture are positive, and loculation and purulent aspiration exist, VATS and thoracotomy should be preferred.

Keywords

Empyema; Thoracoscopy; Thoracostomy; Thoracotomy

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Introduction

Empyema is the collection of inflammation in the pleural cavity which has adhesive properties and dense content. If not treated, the mortality rate is more than % 10 [1]. The most common cause is the complication of parapneumonic pleural effusions occurring due to bacterial, viral pneumonia caused by the infective agents.

Shortness of breath, pleuritic chest pain, cough, purulent sputum, fever, chills, and weight loss are the most common symptoms. Diagnostic is made through invasive procedures such as laboratory and radiological examinations, thoracentesis, bronchoscopy or pleural biopsy [2, 3]. The main treatment methods are observation, thoracentesis, tube thoracostomy, fibrinolytic, video-assisted thoracoscopic surgery (VATS), or thoracotomy [4]. The treatment method to be selected depends on many features such as the cause of empyema, being acute or chronic, the degree of infection, the characteristic features of empyema fluids, the state of the underlying lung, bronchopleural fistula existence, and the general condition of the patients [5]. It is known that the pleural drainage performed at the early stages significantly improves the clinical condition. However, some problems might be encountered if the treatment is performed in the late phase [6].

In this study, we aimed to share the characteristics, factors effective in surgery, and treatment outcomes of surgically treated patients with empyema.

Material and Methods

Patients

One hundred fifty-six patients treated with surgical operations within ten years were analyzed retrospectively in the study. All patients provided written informed consent and the study was approved by Dicle University, Medical School Ethical Committee.

Procedures

The files of the patients were analyzed retrospectively. Age, sex, symptoms, comorbidities, location of disease, diagnostic methods, clinical findings, laboratory tests (pH, lactic dehydrogenase (LDH), glucose) and microbiological (gram stain, culture) results were evaluated.

Surgical methods applied to patients and the results, duration of hospitalization, mortality and morbidity were examined.

Patients were divided into three groups as patients treated with tube thoracostomy, VATS or thoracotomy. The characteristics of each group were investigated. Factors affecting the performance of VATS-thoracotomy instead of tube thoracostomy under local anesthesia, and the application of thoracotomy instead of VATS were investigated.

Inclusion and exclusion criteria

Only the patients treated with surgery were included. Tube thoracostomies applied before VATS or thoracotomy were ignored as

no positive results were obtained. The patients applied fibrinolytic and reached positive results were evaluated with tube thoracostomy group.

Statistical analysis

In statistical analysis for continuous variables were expressed as the mean ± standard deviation and categorical variables were explained as number-ratio. The results were analyzed by the Chi-square and Fisher's exact test. P < 0.05 was considered significant.

Results

The number of patients with pleural effusion treated with surgical procedures in our clinic within ten years was 501, and 156 of those patients (31%) had the diagnosis of empyema. The mean age of the patients was 21.07 ± 17.78 years. 110 (%71) were male, while 46 (%29) were female. All effusions were exudates. The mean pleural fluid was pH: 6.54 ± 0.29, LDH: 863.26 ± 268.21, and glucose: 35.22 ± 5.64. In 26 (17%) patients' gram stain and culture were positive, whereas in 130 (83%), they were negative. It was discovered that in 60 of the patients (38%), loculations existed and in 40 (26%) fluid having purulent characteristics was aspirated (Table 1).

The complaints were shortness of breath (n = 142, 91%), pleuritic chest pain (n = 135, 87%), cough (n = 87, 56%), purulent sputum (n = 48, 31%), fever (n: 43, 28%), chills (n = 43, 28%) and weight loss (n = 23, 15%). The most common comorbidities were diabetes in 21 (13%) patients, chronic obstructive pulmonary disease in 20 (13%), congestive heart failure in 12 patients (8%), extrapulmonary cancers in 7 (4%), and lung cancer in 5 (3%).

The most frequently used radiological method was chest radi-

Table 1. Analysis of patients with empyema

Variable	Treatment procedures			Total
	Tube thoracostomy (Group 1)	VATS (Group 2)	Thoracotomy (Group 3)	
Male (n)	65	5	40	110
Female (n)	29	1	16	46
Right (n)	57	3	29	89
Left (n)	37	3	27	67
pH (average)	6.81 ± 0.21	6.76 ± 0.05	6,31 ± 0,20	6.54 ± 0.29
ldh (average)	663.6 ± 135.09	590 ± 123.9	1092.1 ± 135.5	863.2 ± 268.2
Glucose (average)	39.6 ± 5,1	40 ± 6.1	31.07 ± 2.6	35.22 ± 5.6
Gram/culture (n)	5	2	19	26
Loculation (n)	5	2	53	60
Thoracentesis (n)	94	6	56	156
Purulent fluid (n)	-	-	40	40

VATS: Video-assisted thoracoscopic surgery, n: number, ldh: Lactate dehydrogenase

ography. Computed tomography was the second most common, and thoracic ultrasonography was the third. During the treatment, 94 patients (60%) underwent tube thoracostomy (Group 1), 6 (4%) underwent VATS (Group 2) and 56 (36%) underwent thoracotomy (Group 3). The mean age was 19.70 ± 18.53 in Group 1 ($n = 94$). Sixty-five patients (69%) were male and 29 (31%) were female. Diseases were on the right in 57 (59%) patients, whereas in 37 (41%), it was on the left. The mean pleural fluid was pH: 6.81 ± 0.21 , LDH: 663.67 ± 135.09 , and glucose: 39.65 ± 5.13 . In 5 (5%) patients, gram stain and culture were positive, whereas they were negative in 89 (95%). Loculation existed in 5 patients (5%). In Group 2 ($n = 6$), the mean age was 14.86 ± 22.33 years. Five patients (83%) were male and 1 (17%) was female. Diseases were on the right in 3 (50%) patients, while they were on the left in 3 (50%). The mean pleural fluid was pH 6.76 ± 0.05 , LDH: 590 ± 123.93 , and glucose: 40 ± 6.19 . Two (33%) patients had positive gram stain and cultures, while 4 (67%) had negative. Loculations were present in 2 patients (33%). In Group 3 ($n = 56$), the mean age was 25.18 ± 13.66 years. Forty (71%) of the patients were male and 16 (29%) were female. Disease was on the right in 29 (52%), while it was on the left in 27 (48%). The mean pleural fluid was pH: 6.31 ± 0.20 , Ldh: 1092.14 ± 135.53 , and glucose: 31.07 ± 2.66 . Gram stain and cultures were positive in 19 (34%) patients, while they were negative in 37 (66%). Loculation existed in 53 (95%) patients. It was discovered that liquid having purulent characteristics was aspirated in 40 (71%) patients by

means of thoracentesis.

It was found that gender and localization was not an effective factor in VATS-thoracotomy application. However, gram stain, positive culture results, the presence of loculations and purulent aspiration in thoracentesis were found to have a significant effect on VATS-thoracotomy application ($P < 0.05$). In addition, when VATS and thoracotomy were compared, the presence of loculations was discovered to have a more significant role in thoracotomy ($p < 0.05$) (Table 2, 3).

It was seen that 7 (4%) patients died, 7 (4%) postoperative patients had expansion defect and subcutaneous emphysema, 6 (4%) developed incision infection, and 5(3%) had atelectasis. The mean hospitalization time of the patients was 13 ± 2.5 days.

Discussion

Empyema is rare in healthy individuals. Potential risk factors can be listed as diabetes, alcoholism, gastroesophageal reflux disease, substance abuse and neurological diseases [2]. In our study, the most common concomitant diseases were diabetes, chronic obstructive pulmonary disease, congestive heart failure, lung cancer and other cancers.

Diagnosis is made through clinical, laboratory and radiological findings. Clinical signs vary from weakness to toxic diseases, and shortness of breath, chest pain, cough, purulent sputum, and fever are the most common symptoms. In laboratory tests, leukocytosis, sedimentation rate and C-reactive protein (CRP)

Table 2. Comparison of the treatment procedures of patients with empyema

Variable	Outcome	Tube thoracostomy/ Thoracotomy-VATS	P-value
Sex			
Male	110	65/45	
Female	46	29/17	0.7211
Location			
Right	89	57/32	
Left	67	37/30	0.3218
Gram/culture			
Positive	26	5/21	
Negative	130	89/41	0.0001
Loculations			
Positive	60	5/55	
Negative	96	89/7	0.0001
Purulent aspiration			
Positive	40	0/40	
Negative	116	94/22	0.0001

VATS: Video-assisted thoracoscopic surgery.

Table 3. Comparison of the treatment procedures performed under general anesthesia

Variable	Outcome	Tube thoracostomy/ Thoracotomy-VATS	P-value
Sex			
Male	45	5/40	
Female	17	1/16	1.0000
Location			
Right	32	3/29	
Left	30	3/27	1.0000
Gram/culture			
Positive	21	2/19	
Negative	41	4/37	1.0000
Loculations			
Positive	55	2/53	
Negative	7	4/3	0.0009
Purulent aspiration			
Positive	40	0/40	
Negative	22	0/22	1.0000

VATS: Video-assisted thoracoscopic surgery.

are found to be high. From empyema fluid, pH, protein, glucose, LDH, adenosine deaminase (ADA) levels, cell count, Gram stain, culture, and cytological examination and acid-fast bacilli should be investigated. Although chest X-rays are adequate for diagnosis tomography, thoracic computed tomography is very important to detect underlying parenchymal lung disease, loculations, to separate lung abscess, and to choose the treatment method [1, 4].

The most common symptoms of our patients were shortness of breath, chest pain, cough, purulent sputum, fever, chills, and weight loss. In addition, the most commonly used diagnostic method was chest x-ray. All patients were examined in terms of pleural fluid pH, glucose, LDH, Gram stain, and culture.

The most common cause of empyema is parapneumonic effusions occurring due to bacterial and/or viral pneumonia being complicated by infective agents [1, 3]. Empyema associated with parapneumonic effusions includes 3 periods. During the exudative period, no bacteria existed in pleural fluid, leukocyte is available, pH and glucose are normal, and LDH is low. Antibiotic is sufficient in treatment. In fibrinopurulent period, bacteria and leukocytes are present in the pleural fluid, and septa and loculations are available in the pleural cavity. In empyema fluids, pH is lower than 7.2, and glucose is lower 40 mg / dl, but LDH is higher than 1000 IU / L. In this period, pleural fluid must be drained. A combination of pouch through VATS and fibrinolytic therapy and irrigation is beneficial. During organizations period, thickening and loculations exist in pleura. Thickened visceral pleura prevent the expansion of the lungs. Narrowing in intercostal space, rise in diaphragm, and reduction in hemithoraces volume can be seen. Empyema is displaced toward the side of the mediastinum. Complications such as lung abscesses, bronchopleural fistula, empyema necessitates, rib-spine osteomyelitis, mediastinitis, pericarditis and brain abscess can develop. Decortication should be performed during this period [6, 7]. Ten percent of the parapneumonic effusions turn into empyema as a complication [8]. Pleural effusions are classified into 4 categories according to anatomical, bacteriological, and chemical properties of the fluid [3]. In category 1, pleural effusion, whose pH and culture-gram stain results are not clear and which has less than 10mm level in lateral decubitus graffiti exists. Drainage is not required. In category 2, pleural effusion, whose gram stain and culture results are negative, pH \geq 7.20, and level is greater than 10mm, but less than half of a hemithorax in lateral decubitus graphite. Drainage is not required. In category 3, loculated effusion at least half of a hemithorax, pleural thickening, positive culture-gram stain are present and pH values are $<$ 7.20. Drainage is required. In this group, the risk of complications is moderate. In category 4, fluid at least half of a hemithorax exists. From the expansion defect and purulent fluid, one of the conditions is adequate. Drainage is required. The risk of complications is higher in this group. In this study, the mean pleural fluid for all patients is as follows: pH: 6.54 ± 0.29 , LDH: 863.26 ± 268.21 , and glucose: 35.22 ± 5.64 . In twenty-six of the patients, gram stain and culture results were positive, loculations existed in sixty patients and purulent fluid was observed in 40 patients. In Group 1, the mean pleural fluid was as follows: pH: 6.81 ± 0.21 , LDH: 663.67 ± 135.09 , and glucose: 39.65 ± 5.13 . Five patients had positive gram stain and cultures, and

loculation was present in 5 patients. In Group 2, the mean pleural fluid was pH: 6.76 ± 0.05 , LDH: 590 ± 123.93 , and glucose: 40 ± 6.19 . Two patients had positive gram stain and cultures, and loculations existed in 2 patients. In Group 3, the mean pleural fluid was as follows: pH: 6.31 ± 0.20 , LDH: 1092.14 ± 135.53 , and glucose: 31.07 ± 2.66 . Nineteen patients had positive gram stain or culture, in 53 patients loculations were present, and in 40 patients, purulent fluid aspiration existed.

Basic strategies of empyema treatment are controlling infection and sepsis with appropriate antibiotics, drainage of purulent fluid, correction of empyema cavity, prevention of resistant or recurrent disease and the expansion of the lung tissue. Observation, thoracentesis, tube thoracostomy, fibrinolytics, the removal of adhesions with VATS or thoracotomy, decortication and open drainage are the main treatment methods [4]. The treatment method to be selected depend on the cause of empyema, being acute and chronic, the degree of infection, the properties of empyema fluid, underlying condition of the lung, the radiological findings, the presence of bronchopleural fistulas, being able to close the empyema cavity and the general condition of the patients [5].

Although tube thoracostomy plays an important role in the treatment of empyema, simple tube drainage is not sufficient in 36-65% of patients [1, 9]. Chest tube should be installed in areas where there is a large effusion. This can be done successfully with ultrasound or computerized tomography [10]. After tube thoracostomy, clinical and radiological improvement is achieved in 24 hours. If improvement is not seen, it probably means that pleural drainage may not be adequate. The main reasons for the lack of sufficient drainage are the location of the chest tube in the wrong place, the presence of loculations and visceral pleura confining the lungs. In this case, fibrinolytic therapy with the chest tube should be considered. It may be useful in dense fluids which have multiple loculations and viscosity. Fibrinolytics, eliminating septa, facilitate drainage by combining loculations (chemical decortication). Streptokinase, urokinase, and tissue plasminogen activator are the main fibrinolytics used. Complications such as anaphylaxis, pulmonary edema and hemorrhage may develop. In a study conducted, the routine use of intrapleural fibrinolytic therapy was not recommended due to complications. VATS is a safe and effective method in the case of the presence of multiple loculations which are resistant to fibrinolytic therapy or in which tube drainage with thoracotomy cannot be achieved fully [11, 12].

Video-assisted thoracoscopic surgery yields good clinical results in early interventions such as fibrinopurulent period. Therefore, it is recommended to be applied in 4 weeks [4, 13]. The success rate of VATS in empyema treatment is reported to be 68-93% [14, 15]. VATS also provides an opportunity for taking samples from pleural fluid and pleura. Loculations are combined by opening fibrotic septa and bands in the pleural cavity. Pleural drainage is fully provided. By performing debridement and irrigation, chest tube can be placed into the most suitable localization. Additionally, with the help of this method, pleural plaques which are thickened and prevent lung expansion can be identified, and decortication can immediately be performed. The rate of progression to thoracotomy and open surgical decortication during VATS is between 3.1-40% [16]. Stefani et al.

[5] reported that delayed operations, fever and pleural thickening are decisive factors for VATS cases which are progressed to thoracotomy due to the complete decortication need. VATS is a less invasive treatment method which is as effective as thoracotomy-decortication in the treatment of empyema. In the literature, it has been reported that early surgical debridement results of the patients over 80 years old treated with VATS are excellent, thus advanced age does not create a contraindication to surgery [17]. Decortication is a major application requiring thoracotomy incision. In addition, it must be suitable for the general condition of patients. Decortication is the extraction of fibrous tissue in visceral and parietal pleura, cleaning purulent fluid and debris and ensuring the expansion of the underlying lung. Decortication to thickened pleura should not be performed in the acute phase as the thickening will disappear in a few months. Decortication can be performed in cases where acute period is over in 3-6 months but pleura are still thick and lung functions decrease [18]. By being patient to decortication, parenchymal damage and postoperative air leak should be reduced to a minimum. With swelling of the lungs, pleural space should be filled, and reaccumulation of fluid should be prevented. During the decortication process, mortality is observed between 1.3-6.6% [19, 20]. Despite this mortality rate, decortication process should be applied to suitable indicated patients [21]. In our study, the mortality rate was 4%. Muhammad et al. [6] stated that they have 50% success through intrapleural streptokinase therapy, 92% with VATS, and 100% with decortication in the treatment of complicated parapneumonic effusion and empyema. In this study, 94 of patients were treated with tube thoracostomy, 6 underwent VATS, and 56 were treated through thoracotomy. When the factors for the selection of the treatment method were considered, it was discovered that gender and localization are not effective in performing tube thoracostomy or VATS-thoracotomy, but the positive Gram stain or culture results, the presence of loculations and purulent aspiration in thoracentesis are significantly effective in VATS-thoracotomy application ($p < 0.05$). Additionally, when VATS and thoracotomy were compared, the presence of loculations was found to be more effective in performing thoracotomy ($p < 0.05$).

Open drainage methods are preferred in patients in whom VATS or thoracotomy cannot be performed. There are 2 types of chronic pleural drainage. In Clagett method, which is simple and safe, 1-3 ribs located in the lower part of the empyema cavity are partially resected, a short-thick chest tube is inserted into the empyema cavity and connected to the drain bag. Detoxification is provided by irrigating empyema cavity with antibiotic solutions from the drain. The other method is Eloess, which is more complicated. In this method, a tract is created by using skin-muscle flaps between chest wall and empyema cavity. In the method, 2 or more ribs located in area suitable for empyema cavity are partially resected. Additionally, fistula is formed, and there is no need to use the tube. This application is better tolerated and permits the closure of empyema cavity. In both methods, pleural adhesions are required to not to create a pneumothorax, and they are usually performed at the late period [22]. Recently, mini-vac treatment has been performed to the empyema patients who have a poor general condition and multimorbidity. With this treatment, positive results such

as decrease in empyema cavity, acceleration of lung expansion, and early improvement in empyema [23, 24]. In our study, open drainage methods were not performed.

Consequently, tube thoracostomy is the most commonly used surgical method in empyema treatment. Despite the risk of increased mortality, VATS and thoracotomy should be implemented in cases where tube thoracostomy is not successful. Additionally, VATS and thoracotomy should be preferred in cases where gram stain and culture results are positive, and loculations and purulent aspiration exist.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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